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STATEMENT ON THE SCIENCE AND TECHNOLOGY PROGRAM, (U)

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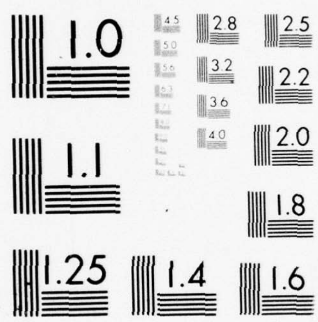

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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STATEMENT ON THE SCIENCE AND TECHNOLOGY PROGRAM

BY

(10) DR. RUTH M. DAVIS
DEPUTY UNDER SECRETARY OF DEFENSE FOR
RESEARCH AND ADVANCED TECHNOLOGY

BEFORE THE

RESEARCH AND DEVELOPMENT SUBCOMMITTEE

OF THE

ARMED SERVICES COMMITTEE

OF THE

UNITED STATES SENATE
95TH CONGRESS, SECOND SESSION

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THE SCIENCE AND TECHNOLOGY PROGRAM

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95TH CONGRESS, SECOND SESSION

9 MARCH 1978

THE FY 1979 DEPARTMENT OF DEFENSE PROGRAM FOR

SCIENCE AND TECHNOLOGY

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Mr. Chairman and Members of the Committee:

It is my privilege this year to discuss with you the Science and Technology Program of the Department of Defense--the program commonly referred to as the "Technology Base". I am accompanied by Colonel Donald I. Carter, USAF, a member of my staff. In addition, other members of the Office of the Under Secretary of Defense for Research and Engineering and of the Services are available to answer questions as appropriate.

I. Overview of the Defense Science and Technology Program

A. Program Purpose

Both the Secretary of Defense and the Under Secretary of Defense for Research and Engineering have identified the Defense Science and Technology Program (S&T Program) as the foundation for maintaining United States technological superiority and the source of the innovative concepts and developments which are the foundation of our future weapons systems. They both have also stated that we are asking for a 7% real increase in the S&T Program for FY 1979.

These are all themes and requests you have heard before. But the words are not idle ones. Advances in science and technology are the primary means by which the future enters into our military systems and planning. If we are, in any way, to exercise control over the manner in which we cope with our military future, then we must possess the managerial mentality to stimulate, pace and utilize our scientific and engineering resources. We believe that our Defense S&T Program provides the foundation for the military future that will be in our best national interest.

Our desire for technological superiority is but one way of asserting the importance of being best in the military competition that engages us as a nation. It is the same measure of success in competition that is used in business or in the marketplace. Being technologically superior gives us an edge in any military conflict or competition and may allow actual conflict to be avoided through the tacit acknowledgment without a fight of the "winner".

Technological superiority which gives us control in the military competitive arena also gives us technological surprise as a powerful weapon. Technological surprise is what we want to make happen to others. If it happens to us, then we must react with a resultant loss in our ability to plan and pace our own scientific military future, and we will have to forego our right to select our own options for orderly military R&D pursuits. Avoiding technological surprise is important in business; it is a national necessity in military matters.

We believe our Defense S&T Program will prevent technological surprises from happening to us while giving us the continuing capability for technological surprise of our potential adversaries.

Measuring whether or not we possess a technological superiority is no easy task, but it is key to measuring the adequacy of our Defense S&T Program. It involves knowing the relative strengths and capabilities of all competitors or adversaries in military environments which themselves must be susceptible to characterization in order to carry out this comparison. In the military sense, as elsewhere, such measurement of relative superiority is in terms of (1) quantity, (2) quality, (3) timing of availability of assets and (4) location of one's assets. Unfortunately, in the case of military competition it is even more difficult to get accurate measurements of one's adversaries than it is in the business marketplace. But continuing to try is essential.

I have developed an illustrative template for use in determining our technological superiority measured in terms of our technological lead time. It is presented as Figure 1 and is for the electronic integrated circuit technology area. We have found it helpful already in determining that we are no longer confident of our continuing technological superiority in the singularly important area of large scale integrated (LSI) circuitry. I anticipate a similar utility of equivalent templates in other technology areas to help identify comparative technological strengths and in setting program priorities.

B. Presentation Format to Congress

My presentation will describe the Services' portion of the overall \$2.6 billion Defense S&T Program. The Defense Advanced

FIGURE 1

MEASURES OF TECHNOLOGICAL SUPERIORITY IN ELECTRONIC CIRCUIT TECHNOLOGY

COMPARATIVE PARAMETERS	IC TYPES	APPLICATION
• PERFORMANCE		
— SPEED — NO. OF CIRCUIT ELEMENTS — RELIABILITY	SSI 500 MHz MSI 50 MHz LSI 5 MHz MSI ABOUT 80% OF PRESENT DOD USE	DETERMINES COMPUTATIONAL CAPABILITY; REAL-TIME USE (TARGETING, FIRE CONTROL, NAVIGATION, EW); NON-REAL TIME USE (WEATHER, MAPPING AND GEODESY, RECCE).
• SYSTEM USE		
— POWER DISSIPATION PER ACTIVE ELEMENT — TOTAL POWER DISSIPATION — SIZE (DENSITY) — WEIGHT	LSI BEST; MSI VERY GOOD	*DETERMINES LIFE CYCLE COST*, ABILITY TO USE (AIRCRAFT, SATELLITES, MISSILES, PORTABLE GROUND EQUIPMENT).
• PRODUCTION CAPABILITY		
— YIELD — THROUGHPUT — COST PER ACTIVE ELEMENT	LSI BEST. CUSTOM LSI CIRCUITS NECESSARY FOR MANY APPLICATIONS.	DETERMINES AVAILABILITY AND AFFORDABILITY.

LEGEND:
LSI = LARGE SCALE INTEGRATION
MSI = MEDIUM SCALE INTEGRATION
SSI = SMALL SCALE INTEGRATION

Research Projects Agency (DARPA) Program will be discussed later this morning. Other portions of the S&T Program are performed by the Defense Nuclear Agency (DNA) and the Uniformed Services University of Health Services (USUHS).

C. Program Investment Strategy

The President has singled out science and technology for attention on several recent occasions and has expressed concern with the falling off in quality of our scientific equipment. the falling off in numbers of our research centers and the corollary need for a new surge of technological innovation. I share that concern which, unfortunately, is also applicable to our Defense S&T Program. Behind these statements of concern is the uncomfortable recognition of signs of decreasing vigor in our science and engineering enterprise and of inadequate merging of our scientific and national policies.

The phraseology "investment strategy" can be meaningfully applied to the Defense S&T Program if done in terms of improving our competitive position relative to our military rivals. I addressed this competition in the previous section and would simply highlight here that we are employing an investment strategy that uses our national technological advantages to provide a military technology future characterized by confidence, orderly development and absence of debilitating technological surprises.

It is in this sense that I present today the Defense S&T Program for FY 1979.

Our request for FY 1979 for the Defense S&T Program is $2.6 billion. Placed in context, this program represents 9% of the total Federal research and development obligations and contains approximately 14% of the total Federal research and development obligations, less weapon systems and non-S&T Defense R&D obligations. The overall DoD request provides a real funding growth over FY 1978 of 7% in Research, 4% in Exploratory Development and 15% in Advanced Technology Demonstrations.

The funding in these three categories of our Program is as follows:

S&T Program Request
(Dollars in Millions)

Program Category	Funding FY 78	Funding FY 79
Research (6.1)	$ 412.4	$ 468.3
Exploratory Development (6.2)	1,384.5	1,531.7
Advanced Technology Demonstrations (6.3A)	486.9	592.8
Total	$2,283.8	$2,592.8

This proposed growth is designed to provide more options and wider selectivity for future systems development. It is at this inventive and innovative beginning of the weapon systems acquisition cycle--the science and technology component--that ideas are developed and evaluated at low cost prior to the commitment of large resources for prototyping and development. The proposed growth is also aimed at expediting the progress of ideas and inventions from their conception to technologically superior fielded weapons and logistics systems. Reducing the length of the overall R&D cycle time is essential to match the Soviet's ability to rapidly exploit new technology advances.

The S&T Program covers the spectrum of critical military technologies from munitions, guidance and control and electronics through materials, mathematics and physics, through oceanographic and environmental sciences to chemical and biological defense and to the vital areas of training, safety, food, nutrition and life sciences. The S&T Program addresses the important objectives of (1) providing the most technologically effective and safe environment possible for the individual engaged in a combat situation, (2) providing the most technologically advanced and effective weapons and defensive systems for all combat arenas ranging from space to underseas and (3) expediting the progress of ideas and inventions from their conception to their final manifestation as technologically superior fielded weapons and logistics systems in our military inventory.

The S&T Program is accomplished by a combination of 78 DoD in-house research and development activities, 150-175 universities and a wide segment of industry. For management purposes, it is separated into the technology areas shown in Figure 2.

Figure 2

The Technology Areas of the DoD
Science and Technology Program with Associated Funding
(Dollars in Millions)

Technology Area	FY 77	FY 78	FY 79
Propulsion for Missiles and Space	46	52	66
Aeronautical Vehicle	106	108	113
Aircraft Propulsion	93	99	113
Guided Missiles and Rockets	76	78	99
Guns	79	85	94
Torpedoes and other Underseas Warfare Weaponry	23	19	21
Landmines, Landmine Countermeasures and Barriers	13	18	18
Ocean Vehicles	114	118	138
Land Mobility	26	26	47
Materials and Structures	114	121	129
Bombs and Clusters	11	10	11
Research	338	370	419
Electronic Devices	59	62	68
Electronic Warfare	46	55	63
Search	90	93	99
Target Exploitation	34	38	28
Command and Control	44	45	57
Communications	14	16	19
Information Processing	19	17	22
Medicine and Life Sciences	116	126	141
Training and Personnel	82	91	103
Environmental Quality Research and Development	33	29	32
Environmental Sciences	122	139	146
Chemical Warfare and Chemical-Biological Defense Research and Development	39	37	50
TOTAL	1737	1852	2096

The diversity of the S&T Program is one of its key strengths. Diversity in this sense is not to be confused with complexity. I share Dr. James Killian's views which emphasize the importance of maintaining this diversity. Dr. Killian stated in 1977:

> "The Russians were able in the 1950s, and are able today, to meet any <u>single</u> challenge the American economy can offer. But they have not, in the field of technology proved capable of meeting <u>all</u> the challenges the American economy can offer. They managed in the 1940s and 1950s to build a nuclear capacity and a missile capacity. The United States managed in the same time period to build those two capacities and at the same time to provide...a submarine nuclear striking force aircraft industry that provided most of the world's transport planes, an enormously advanced computer technology, an extraordinary broad-band communications facility, plastics and synthetic fibers, a rapidly advancing medical technology, and a host of other achievements.... At the same time American scientists had achieved world leadership in basic science."

(Dr. James R. Killian, First Special Assistant to the President for Science and Technology.)

This national prowess was due in no small measure to the Defense S&T Program. It is a continuing challenge which can be met only through the diversity and high impact programs resident in the S&T Program as we proposed it for FY 1979.

II. Selected Major FY 1979 Program Thrusts

I will focus here on some program thrusts of particular significance that illustrate the importance and criticality of our FY 1979 program.

A. Precision Guided Weapons Technology

Dr. Perry, the Under Secretary of Defense for Research and Engineering, highlighted in his FY 1979 program presentation to Congress the potential of precision guided weapons for revolutionizing warfare. Efforts in our FY 1979 S&T Program are key to realizing this potential. The example I will cite is in precision guidance technology.

We are developing the means for employment of precision guided munitions against the enemy's second echelon forces in Europe. The scenario against which we are working is typified by a Soviet armored penetration in which two armored divisions make a frontal attack across the FEBA with a third division in reserve in the second echelon. When the two frontal divisions have effected the penetration, the reserve division is committed to exploit that penetration.

Considerable effort over the past few years has gone into providing our front line forces with a direct fire anti-tank capability to blunt the initial assault. Our direct fire precision guided munitions such as the TOW, Dragon, HELLFIRE and Maverick and unguided munitions such as the Light Anti-tank Weapon (LAW), 105mm tank gun and GAU-8 are expected to blunt a numerically superior force. Our forces can anticipate an acceptable amount of attrition against enemy frontal forces. We believe it imperative to be capable of exacting destruction of the Soviet second echelon forces using direct and indirect fire precision guided munitions. We now have a limited capability to strike point targets in the enemy's second echelon.

Without significant technological advances, our forces cannot be expected to stabilize the battlefield. Recognizing the shortcomings of our current systems we are striving to provide improved capability in the near term and a fully effective capability in the outyears.

With the advent of microelectronics and advanced computer technology, we are now on the verge of developing unique terminal guidance signal processing techniques which will permit a munition delivered into the target area to scan the cluttered battlefield background. Using new imaging and, in some cases, non-imaging infrared seekers the target can be acquired and hit day or night. What remains, however, to provide a fully effective capability is the development of seekers that can see through bad weather, smoke and dust. Precision guidance technology programs identified in the FY 1979 budget are directed toward the demonstration of an effective fair weather capability and development of all-weather sensors. Specific demonstration programs involve the Terminally Guided Submissiles (TGSM) for the Army's General Support Rocket System which is responsive to previous Congressional direction, TGSM for the MINI-missile concept in the Air Force Wide Area Anti-Armor Munitions Program, and TGSM for the DARPA sponsored Assault Breaker Program. These efforts are directed toward destruction of enemy armor which has not yet reached the range of our direct fire weapons. Longer term technology development in the area of millimeter wave (MMW) sensors is directed toward the destruction of enemy armor in adverse weather. The FY 1979 budget requests $14.6 million to advance the state-of-the-art of solid state MMW devices and to conduct some limited demonstrations. This information is critical to the development of the signal processing techniques which insure acquisition of the proper target regardless of the weather and other battlefield conditions.

Our planned efforts in precision guided munitions, if successful, could well revolutionize conventional warfare to our advantage.

B. Charged-Particle Beam Technology

Charged-particle beams (CPBs) of high currents and high energy represent an advanced stage of technological development capable, at least in principle, of superseding mechanical systems limited by inertia or of performing new functions not before possible. As an instance, present-day tactical weapons delivery systems respond and deliver warheads to their targets in times measured in seconds. The use of projected beams in weapons systems is based on bringing the charged-particle beam to a target and causing an intensive interaction between the beam energy and the target material in a matter of milliseconds (thousandths of a second). This represents a gain of 1,000 in the speed of response and delivery of warheads over conventional weapons, provided, of course, that we can solve the formidable scientific and technical problems involved. Such a technological advance in weapons delivery could radically change warfare.

Considerable confusion, misconceptions and uncertainties have clouded discussions and developments in charged-particle beam technology. We recognize these difficulties as well as the potential, that should not be ignored, of CPB devices to provide novel solutions to a number of specific problems calling for the rapid delivery of high energy at high density and with considerable precision, either in the form of material particles (electrons, protons, heavy ions or neutral atoms) or, after conversion, as photons (X-ray, infrared or microwave radiation).

Accordingly, I have had prepared a just-completed management plan which addresses charged-particle beam technology in terms of the associated scientific issues and uncertainties on the one hand and the application areas on the other hand. The intent was (1) to determine the extent of the remaining scientific uncertainties and the probability of eliminating the uncertainties along with the attendant costs and (2) to ascertain the objectives of on-going R&D efforts and their relevance to addressing major scientific uncertainties and to needed developmental activities.

This management plan specifically identifies areas of R&D where no particular problems lie, areas of major uncertainty, and areas of critical deficiency requiring high priority for a variety of applications including fusion-plasma heating, inertial fusion, advanced simulation, laser pumping, radiation core ECM, and microwave generation in addition to projected beams. Also, the study indicates what is being done today to realize the above applications, indicating ongoing efforts and which stage in the R&D cycle the effort lies. This study will provide the guidance to direct our future technology efforts in the most effective manner.

Because of the technological potential as well as the real need of preventing technological surprise from happening to us in charged-particle beam applications, we plan to allocate $6 million above of the previously planned amount of $5.6 million to high priority CPB projects in FY 1979.

C. Chemical and Biological Defense Technology

We know that the threat of chemical and biological warfare from the Soviet/Warsaw Pact forces is significant and increasing. They are the best equipped and prepared forces in the world to employ chemical weapons and to operate under chemical and biological warfare conditions. They maintain extensive training facilities and a large, well-equipped and well-trained organization which is organic to their force structure. It is entirely likely that the Soviets would consider using a combination of conventional and chemical weapons, as well as a combination of chemical and nuclear weapons if they believed a significant tactical advantage could be gained.

We are, of course, prohibited from first use of chemical weapons by the Geneva Protocol and any use of biological weapons by the Biological Weapons Convention. The Soviets are also signatories to these treaties. However, as a direct result of a discernable increasing threat, we are increasing defensive measures to insure the survivability of our conventional and theater nuclear forces. Our program is funded at $57.8 million in FY 1979 and emphasizes improved prophylaxis and therapy, automatic detection and warning devices, individual protection equipment, personal decontamination, and collective protection equipment. A new project in FY 1979 is directed toward developing training materials and devices to support the training and doctrine development necessary to an adequate protective posture. The goal is to attain a more adequate fielded protective posture in the near term with continual improvements thereafter.

As one example of improved prophylaxis and therapy against chemical warfare in our FY 1979 program, I would highlight the effort to qualify pyridostigmine as a prophylaxis with the Food and Drug Administration. The prophylaxis, when combined with the new antidote (TAB), provides substantially improved protection over the antidote alone in test animals against the primary threat agent, yet it is harmless to the animal at the recommended dose level, even when used over an extended period of time. Another example is the new individual protective mask which reduces the burden on the individual wearer and will, therefore, increase his combat capability.

The development of safe binary munitions is an important facet of our deterrent posture. By binary munitions, I mean those in which two non-lethal chemicals are packaged separately and only after firing toward the target are the contents mixed to form our standard never agents GB and VX. These binary munitions will provide significant advantages in manufacturing, storage, surveillance, transportation and disposal.

FY 1979 funding for binary munitions is $4.9 million. Of this funding, $2.2 million is to complete the development of the Bigeye binary VX aerial bomb. This is to buy prototype hardware and perform the necessary testing for function, reliability and environmental rough handling. Support to the 8-inch VX projectile will require $0.2 million, and the remainder, $2.5 million, is aimed at agent and munition design.

The decision of whether or not to request funds for the production of binary munitions has not been made. We will review this area in conjunction with progress in arms control negotiations in the near future. If sufficient arms control progress has not been made, the DoD may again request funds for the construction of an integrated binary munitions production facility. Planning is continuing for a modular type facility capable of manufacturing at one site a variety of items, essentially ground-delivered and air-delivered systems, with common utilities, security and safety features.

D. Materials Technology

In the early 1970s reentry vehicles launched from Vandenberg Air Force Base encountered adverse weather conditions in the Kwajalein Island impact area and experienced anomalous aerodynamic behavior. The anomalous reentry performance was attributed to excessive erosion of the nose tip and/or heatshield of the reentry vehicles.

The suppositions of these early flight experiences were reinforced by a series of rain erosion tests at the Holloman Air Force Base Test Track using full scale reentry vehicle nose tips. Recovery and post-test examination of the test items revealed the reality and extent of the erosion damage that could occur in a rain environment.

These circumstances triggered a major effort in the reentry vehicle development community and led to a systematic flight test program called the Sandia-Air Force Materials Study in the 1971-1976 time period. A wide variety of nose tip materials and configurations were flight tested in both clear air and in adverse weather conditions. Altogether 39 flights were conducted.

The extensive series of flight tests and associated ground tests referred to previously conclusively demonstrated the potential seriousness of the erosion phenomena and indicated that the nose tip materials developed in the Science and Technology Program probably were the most promising technological direction to follow to improve the erosion performance of reentry vehicle nose tips.

There is still much to be learned about these complex materials but their flight test performance has fully justified continued strong technological involvement. While current composite materials meet most of the requirements, they do not perform acceptably under severe environmental conditions.

Quantitatively, our goal is to develop erosion resistant nose tip and heat shield composite materials which in severe weather will yield a reentry Circular Error Probability no greater than that now achievable with present day materials under clear air conditions.

Our work now is basically exploratory; however, in order for the results of the S&T Program to impact future Navy and Air Force strategic missile systems, we must evolve an optimum material configuration in the early 1980s if these materials are to be available for reentry vehicle designers in the mid- to late 1980s.

The presently planned FY 1979 funding for this program is about $1.6 million.

E. Electronic Warfare Technology

Negating the anti-ship missile (ASM) by electronic means is a major objective of our electronic warfare (EW) program. Soviet denial of our sea lanes would probably be attempted through the use of ASMs launched from Bear and Badger land-based long-range aircraft, Charlie class attack submarines, or the growing Soviet fleet of modern surface combatants. The seriousness of this threat and the potency of electronic warfare to negate it was demonstrated in the October 1973 Middle East conflict. In one engagement 4 Israeli patrol boats, using U.S. developed chaff rockets, evaded over 20 Styx ASMs fired at them by 11 Syrian gunboats, then returned a salvo of ASMs which hit all 11 Syrian boats. The Syrian boats were without EW protection.

Our anti-ship missile defense (ASMD) EW program has four facets--detection, signature suppression, decoying and jamming.

Primary detection of ASMs is presently accomplished by receiving the emission of their active radar seekers. To improve our detection capabilities, we are developing jointly with Canada a passive infrared search and track system (IRST). Advanced development tests have been conducted and the next improved version will be tested in FY 1979, leading to a joint engineering development in FY 1980.

Signature suppression is primarily concerned with reducing the signature of ships. We are developing techniques to hinder acquisition of our ships by ASMs. A second benefit from lower ship signature is that it will allow us to use decoys to present a credible counterfeit of the ship signature.

Decoys are the primary ASMD today. Our exploratory development efforts are concentrated on making improvements in decoys against ASMs. We are supporting engineering development of expendable active RF repeaters. Active RF repeaters can be packaged in a small rocket launched decoy.

Jamming by on-board EW equipment, as opposed to launching of expendable decoys, is highly desirable because decoys require good timing in their release to be effective, thereby placing a difficult burden on the detection and tracking of the incoming ASMs. Also, the number of expendables which can be carried is always limited and may not be adequate to handle a massive barrage of ASMs. We are seeking a generic solution to the problem using on-board jammers. These techniques will also have applicability to the protection of aircraft from surface-to-air missiles, and we have initiated a coordinated Navy/Air Force effort exploring airborne versions of the system.

Future ASM threats are postulated to include laser guided seekers, and investigations have been initiated this year to explore countermeasures against them.

The FY 1979 funding for the ASMD electronic warfare program is $12.6 million.

F. Electron Device Technology

We have been complacent about our lead in integrated circuits (ICs), assuming that our rapid advances would keep us well ahead of the Soviet Union. However, recent information has indicated that our lead has been eroding rapidly.

Why has this lead eroded? One of the reasons is that we have relied on the consumer-oriented electronics industry to meet our needs in ICs where DoD now constitutes only 7% of the IC market.

But we need specialized high speed ICs not in demand in the consumer market. One urgent requirement is for pinpoint precision for a cruise missile. The addition of a three dimensional scene correlation capability for the terminal phase of the flight (photo matching) would enable the missile to hit within a few feet of the desired aim point. This requires a very small computer with a much faster throughput than is presently available.

Similarly, very fast computers are needed for our future satellites, and even our ground-based systems. For example, Army SIGINT systems will have to handle thousands of radar systems in the 1980s. Full ocean-basin surveillance will also require very high speed throughputs.

To achieve computer speeds with the needed size, weight, power and reliability characteristics, we must have higher speed ICs. This will involve reducing the fabrication dimensions from the present five-micron level to submicron dimensions. New technology such as electron-beam, ion-beam or X-ray lithograpny is required to reach these dimensions. New processing steps such as low temperature epitaxy and ion-beam milling will have to be used, and newer materials including gallium arsenide will be needed.

We are initiating a major new program on very high speed ICs to redirect industry's attention towards military needs. The program will last for about five years and will shorten the time to achieve these very high speed ICs in from five to ten years ahead of present industry projections. The program will double our present expenditures of about $10 million annually on advanced ICs, and will result in having not only MILSPEC qualified ICs, but will also include demonstrations of needed signal processing subsystems to shorten the time to system use. The new program will start in FY 1979 from our present funds at a level of approximately $20 million.

G. Training and Simulation Technology

Realistic training in peacetime for combat and for emergency situations with safety to personnel and equipment continues to challenge the Department of Defense training organizations. Technology advances in several areas, such as computers, electronic devices and optics, are dramatically increasing the technical and economic possibility of using training devices and simulators to train realistically and safely. The spectrum ranges from flight simulation to combat engagement simulation to maintenance training simulation.

While there is no question about the effectiveness of flight simulators, there is a great deficiency with regard to cost-effectiveness information. A recent cost-effectiveness evaluation of the use of a new Navy simulator for the P-3C indicates that sufficient flight time has been saved to amortize the simulator procurement costs within two years. Our FY 1979 program will focus on use of a cost-effectiveness model to guide and in-house R&D programs of training devices and simulators and also to provide operational command support.

In terms of technology, the primary deficiency is in the area of visual scene generation and display. Limitations in visual simulation are currently the prime deficiency in the development of major operational trainers, especially aircraft flight simulators. High fidelity visual systems are required which provide non-programmed, real-time, dynamic, wide-angle displays featuring high resolution, life-size and natural color characteristics in the scene. Our FY 1979 program in this area includes development, funded at $3.2 million, of an advanced visual simulation technology for future fighter/attack aircraft simulators for aircrew training. Our efforts will utilize the low cost, holographic, in-line, infinity optical display technology currently being developed and will continue the development of the high-resolution, high-brightness liquid crystal light amplifier projector. We will use advanced Computer

Image Generation techniques in the form of new texturing, feature generation and other image improvement algorithms currently in exploratory development to provide the image sources and to enhance the scene detail in the ground plane. These developments will provide relatively low-cost, wide field-of-view imagery with multiple high resolution moving targets applicable for both air-to-air and air-to-ground simulation of tactical air combat mission scenarios. We expect this effort to be completed by the end of 1982.

H. Fighter Aircraft Maneuverability Technology

In any general conventional war with the Warsaw Pact, we anticipate that we will be outnumbered in the air. A lesson learned during the Arab-Israeli War was that we will face an extremely dense multi-tiered air defense net on the ground. For our tactical aircraft we need to increase fighting effectiveness, we need to increase survivability, we need to decrease exposure time and we need to do all these at reduced cost so that we can, through technology, overcome numerical inequality.

Our major thrust in fighter maneuverability is aimed at developing and demonstrating the technologies to meet these needs. They are the individual technologies of digital flight control, six degree of freedom aerodynamic control, and high acceleration cockpit technology from which we will demonstrate an integrated capability to improve our fighter maneuverability.

With digital flight control, we can directly integrate fire control system commands with aircraft maneuver response and can develop weapon line aiming independent of aircraft flight path. In air-to-air combat this aiming capability alone is expected to increase available gun shoot time considerably. In air-to-ground delivery of unguided bombs we expect to reduce bombing errors and to increase the probability of kill.

The high acceleration cockpit will permit a pilot to double the turn rate at which he can remain alert and in control. He can achieve this through reduction of the vertical distance from heart to head with associated reduction of the "G" forces, thus enabling the heart to better maintain blood supply to the brain. Our simulator studies indicate a reduction in time spent in high acceleration flight and improved effectiveness by enabling the pilot to bring his weapons to bear sooner. In air-to-air engagements, the high acceleration cockpit is estimated to increase kills significantly and cut losses. In air-to-ground weapon delivery, it permits fast pull-outs which will reduce exposure to enemy air defense weapons to a fraction of that for conventional delivery.

These advances will be demonstrated with a modified F-15 or F-16 in the Advanced Fighter Technology Integration (AFTI) program for which we are requesting $4 million in FY 1979. The individual contributing technologies will be developed in the Flight Vehicle Technology Program for which we are requesting a $8.9 million in the Air Force budget and $3.3 million in the Navy budget for FY 1979. We expect to begin flight tests in FY 1982 and complete the demonstration in FY 1983 in time to affect advanced tactical systems for the Air Force and V/STOL aircraft for the Navy.

I. The Defense Science and Engineering Program (DSEP)

The President, in his State of the Union message and on several other occasions, has expressed concern about the poor health of our academic research community and the potentially harmful effect of this on future innovations. He particularly cited the decrease in quality of scientific equipment and the aging of research faculty members in U.S. universities and colleges.

The DoD has had a traditional and long standing relationship with the academic research community which dates back to World War II. At one time, in fact, DoD was the backbone of science and engineering support in the nation. That support has led to a number of important discoveries which today are taken for granted in our military systems. Examples include radars, computers and lasers.

Recently, we have become aware and concerned about the weakening of these traditional ties which have resulted, in part, from the 50% decrease in real dollars over the last decade for university research.

Accordingly, we decided to initiate a new DoD university program, referred to as Defense Science and Engineering Program (DSEP). We were supported in our decision by:

- The Defense Science Board Summer Study (1976) which recommended a new program in DoD to rekindle and stimulate the interest of the academic research community in problems of national defense, and

- The Director of the Office of Management and Budget who, in a 15 August 1977 memorandum, stated that "the President has expressed his interest in having Federal departments examine their R&D programs to ensure an appropriate balance between basic ... and applied research and development." The memo continues by asking agencies to identify critical problems where basic research could assist in carrying out the agency's mission.

Our objectives for the DSEP program are to (1) improve our national defense capabilities in the long-term, (2) more fully utilize the scientific creativity and engineering inventiveness resident within the academic research community and (3) broaden and strengthen the relationship between the defense and academic research community. FY 1979 funding for DSEP is $9 million.

DSEP will be an integral part of the Defense Research Science Program although, because of its unique nature, each Military Service has set it aside from its regular mode of operation. Additionally, for an initial period, OUSDRE will provide direct oversight to ensure close coupling of DSEP projects among the Services. Key research problem areas are being identified, and funding will be focused so that meaningful efforts are directed toward their solution. I should point out here that DSEP is not an institutional aid program like THEMIS nor is its objective to build up geographically distributed university research centers.

Rather, the DSEP Program will emphasize research that relates to broad problem areas characterized by scientific and engineering uncertainties which can best be resolved by the expertise resident within the academic research community.

The determination of research problem areas will generally be by DoD managers in conjunction with interested groups from the research community. Although research problem areas may be contemporary in nature, they will most often be oriented towards the future, matching the anticipated time span of most research.

The selection of broad research problem areas as a rallying mechanism for DSEP is intended to:

1. Expedite the contracting (or grant) process,

2. Serve as guidance or stimulus to the academic research community,

3. Provide a focus of concentration in U.S. science and engineering directed towards maintaining or increasing our technological superiority in the future,

4. Assist in eliminating unnecessary redundancy in federal government-sponsored research, and

5. Permit some continuity over time of research activities.

Examples of possible broad generic research problem areas include:

- Physical properties manifest at near absolute zero temperature, e.g., supermobility, magnetic characteristics, etc.
- Proving the correctness of computer software.
- Erosion-resistant material science.
- Surface physics and chemistry.
- Real time system monitoring and control.
- Non-destructive evaluation processes.
- Beam propagation (particle and light) through natural media, e.g., atmosphere, underwater, surface.
- Computing complexity.
- Risk analysis.

It is my hope, shared by the Secretary of Defense and the Under Secretary of Defense for Research and Engineering, that the DSEP Program will be a major contributor to our future technological strength and to the continuing support of our national security by the academic research community.

III. A Management Perspective of the DoD Science and Technology Program

A. Management Goals and Actions

One of the responsibilities associated with good R&D management is that of stimulating the available scientific and engineering talent to make its maximum possible contribution; a correlary managerial responsibility of equivalent importance is to exploit to the fullest the products of the national scientific and engineering community. I consider these closely related tasks to be two of the most complex and demanding but also rewarding ones of my office.

The Department of Defense has not only the national industrial and academic technology base, but also some 78 of its own in-house R&D activities to encourage and to utilize for its special mission-oriented research and development needs.

There are a variety of actions which must be continually underway in my office to adequately stimulate and utilize available scientific and engineering resources. Some of them are:

1. To interact with the scientific community to the extent that it adequately understands DoD's scientifically-based problems and can respond to them.

2. To provide the structured mechanisms between R&D groups and operational military organizations that will allow the needed two-way flow of information and results on mission needs and R&D capabilities.

3. To prevent any crippling dependency by DoD on a specific segment of the scientific community that could harm DoD's ability to be properly responsive to its mission needs.

4. To be assured, especially in rapidly changing technologies, that scientists and engineers in DoD laboratories or on DoD projects have the means and the requirement to keep scientifically current.

5. To keep to a minimum the time period between relevant invention or creative idea, and its first developmental application in an operational environment.

6. To maintain high morale and dedication among scientists and engineers in DoD laboratories and on DoD projects that is as necessary to national security as is the same high level of morale and dedication among our uniformed Services.

7. To recognize and then provide the incentives for uniformly high quality in our research and development activities.

8. To smoothly transition the substance of our R&D programs so that it always mirrors the best of the old and the best of the new from our rapidly changing scientific environment.

I would like to report that I am satisfied with our performance in all these areas. I cannot so do, but I conjecture that my inability here reflects more of an impatience with the pace of activities than of any basic failure in our management philosophy.

B. Participant Balance in the Program

You heard last year and in previous years, for example, that a principal objective of my predecessor was to move back to the ratio of the mid-sixties for balancing the participation in the Defense S&T Program by DoD laboratories on the one hand, and by academic and industrial R&D organizations on the other hand. This resulted in direction to the Services to reduce to about 35% the in-house component of their S&T Programs (the Technology Base). I will report shortly on the results to date in achieving this numeric metric or goal. First, however, I want to emphasize that unless such an attempt to effect change is accompanied by companion attempts toward program improvement, the result could almost certainly be predicted to be disappointing in its effect. Accordingly, I have initiated a set of follow-on actions intended to stimulate and utilize our scientific assets to their benefit as well as to DoD's benefit.

Next, let me report on the progress within DoD of the highly impactive efforts since FY 1975 to reduce the percentage participation of DoD laboratories in the DoD S&T Program.

Since 1975, concerted efforts have been made to impose a requirement that no more than a specified maximum percentage of the total S&T Program could be performed in-house by the Services. To date, the result has been a reduction in the percentage of the S&T Program performed in-house from about 43% in FY 1974 to about 37% at the end of FY 1977. The change results primarily from a larger portion of the S&T Program increases going to universities and industry.

In FY 1977, in the DoD Research Program (about 18% of the S&T Program) some 40% of the work was carried out by DoD in-house laboratories, 40% by universities and 20% by industry and non-profit organizations. As would be expected, this program balance shifts increasingly from universities through the DoD laboratories to industry during the progression from Research through Exploratory Development to the Advanced Technology Demonstration component of the S&T Program. In the latter program the effort is about 70% in industry and 30% in DoD laboratories. We do not see any major pertubations in these ratios for FY 1978 or the out-years.

Between the three Services we note the following changes:

Service	Effort Done by Percentage of DoD In-House FY 1975	FY 1977
Army	66	56
Navy	45	38
Air Force	42	42
Total DoD	42	37

I am sensitive to the various views within the Executive Branch, Congress and industry as to the proper balance between the performers of S&T work for DoD. The views of the House Armed Services Committee were expressed in section 809(c) of Public Law 95-79 which placed temporary limits on the amount of Research and Exploratory Development that could be performed by private contractors. The Senate's view was expressed in its statement that "the strength of this country will continue to be the initiative and motivation provided by our free enterprise system. Current trends preventing more participation by non-Department of Defense laboratories must be reversed and done so quickly and dramatically."

This range of views highlights the inadequacy of any single factor, such as a numerical metric goal, for designating the distribution of the S&T Program between performers. We note for instance the calculated variability of the internal versus the contracted-out R&D by just 5 of the 78 in-house R&D activities, each specializing in a different technology:

Laboratory	Percentage of S&T Program In-House (FY 1977)
. Institute of Environmental Medicine	96
. Large Caliber Weapons Systems Laboratories	72
. Combat Surveillance and Target Acquisition Laboratory	46
. Air Force Avionics Laboratory	31
. Air Force Aero Propulsion Laboratory	27

This distribution reflects the past history of the Services (Army and Air Force), the available industrial vs laboratory capability in any one sector (e.g., large caliber guns as contrasted with aeronautical technology), and, to an extent, the breadth of the commercial base of the technology (e.g., aircraft propulsion). I do not believe that such data allows one to categorically decide that one laboratory's work is better than another's simply because one performs more of its work in-house and the other more on contract.

C. A New Management Initiative

In this regard, as I indicated, I have initiated a set of specific activities aimed at meeting my responsibilities for policy management of the Defense S&T Program. To repeat, my overall objectives are two-fold: namely, to more fully stimulate and to better utilize our available scientific and engineering assets in pursuit of DoD's mission. The criterion for assessing what change or improvement is needed will be the extent to which the eight supporting managerial actions listed previously are being adequately pursued.

Although the general objectives and supporting mechanisms of good management are universal, the differences in their realization and the required remedial actions will almost always vary from one scientific or engineering area to another. For example, technological advances occur both in what we term incremental improvements and as technological breakthroughs. Management must be on the look-out for both and be aware that its actions can be instrumental in the relative encouragement provided to each type of progress. In propulsion technology we have generally seen incremental improvements occurring during the last 20 years. These incremental improvements are then assimilated into new engine developments that are initiated every several years. Although these component improvements may be individually small in nature, they result in a step improvement in each new engine development. For example, the thrust to weight ratio of the J79 engine for the F-4 aircraft in the mid-fifties was approximately 4.5 to 1; the thrust to weight ratio of the TF30 engine for the F-14 aircraft in the late sixties was approximately 6 to 1, and now in the seventies the thrust to weight ratio of the F-100 engine for the F-15 aircraft is approximately 8.5 to 1. Overall, 20 years of incremental improvement have nearly doubled the capability of aircraft engines.

Computer technology on the other hand has been characterized over the last 25 years by technological breakthroughs such as magnetic core memories, transistors, semiconductors and large scale integrated (LSI) circuitry. Good management of these two technologies to realize the same objectives will require significantly different approaches.

As another example of differences in technology, we note that ordnance technology does not have a competitive domestic marketplace as a stimulus for its advance. Its customer is the military. Managerial actions to promote rapid technological advance in this field must, of necessity, be dramatically different from those for electron devices for which there is a highly competitive, consumer-dominated marketplace.

With these examples as symptomatic of the wide variation between the scientific areas of our S&T Program, I intend to obtain suggestions for improvement and to take action to accelerate our technological momentum on a technology-specific basis. The totality of these actions will be a comprehensive, balanced S&T Program-wide improvement plan marked by an understanding of the features which distinctively characterize each of the components of the S&T Program. The specific management effort will occur over a period of 2 years with half of the 24 technologies being reviewed for recommended ameliorative actions each year as follows:

1978-1979	1979-1980
. Guided Missiles	. Guns
. Materials and Structures	. Aeronautical Vehicles
. Bombs and Clusters	. Aircraft Propulsion
. Propulsion Technology: Missiles and Space	. Torpedoes and Other Undersea Warfare Weapons
. Environmental Science	. Search Equipment
. Training and Personnel	. Target Exploitation
. Environmental Quality	. Command and Control
. Chemical Defense	. Medical and Life Sciences
. Landmines and Countermeasures	. Ocean Vehicles
. Electronic Warfare	. Research
. Land Mobility	. Electronic Devices
. Information Processing	. Communications

We are putting together teams of scientific experts, operational users, systems and procurement specialists and R&D managers (9-15 people per team) and asking them to address specific questions and assess each S&T area against the 8 criteria cited earlier. The numerical balance goal of the past three years will then become one parameter of the assessment to be melded into a technology-specific set of recommendations.

I will report periodically to you on progress made. I am both expectant and impatient for the opportunity to responsibly and responsively take steps to make our DoD science and technology resources even more a national asset than they already are.

D. Cooperative R&D Program with Our Allies

The Under Secretary of Defense for Research and Engineering, in his statement to the Congress, emphasized the need to selectively share technology with allies so that weapons developed will have the benefit of each other's research and development. The S&T Program provides an area where the exchange of technical information, coordinated research and cooperative research can be identified and carried out. Two programs foster this objective. The Defense Research Group (DRG) provides a regular and systematic basis for achieving these goals within NATO. Typical work accomplished by DRG includes anti-armor analysis, design of high-speed naval surface vessels and electronic warfare vulnerability studies. The Technical Cooperation Program achieves similar goals between the Australian, New Zealand, Canadian, United Kingdom and United States Defense Departments and is particularly effective in such areas as materials, chemical defense, electro-optical and undersea warfare where opportunities exist for the integration of programs to increase the total science and technology output. Both of these programs have procedures for regular and systematic transfer of technology at both policy and working levels.

E. Federal Contract Research Centers' Participation in the DoD Research, Development and Acquisition Program

The Department will have six Federal Contract Research Centers (FCRCs) to assist in the performance of the FY 1979 Research, Development and Acquisition Program. FCRCs are a subset of Federally Funded Research and Development Centers used by several Departments for the performance of important parts of their missions. The DoD FCRCs are as follows:

Studies and Analyses (S&A) FCRCs

Center for Naval Analyses

Institute for Defense Analyses

Project AIR FORCE (Rand Corporation)

Laboratory FCRC

MIT Lincoln Laboratory

System Engineering and Technical Direction (SE/TD) FCRCs

Aerospace Corporation

MITRE Corporation

The major portion of the Department's use of the FCRCs is for the System Engineering and Technical Direction FCRCs (MITRE and Aerospace) which will consume about 65% of the estimated $294 million that will be used in the performance of Research, Development and Acquisition by the FCRCs. This support is required for the workload in the Space, Command and Control and Communications (C^3) acquisition programs which is a rapidly increasing and important portion of the total defense program. The Air Force is the predominate user of SE/TD support as they do not maintain extensive in-house technical organizations for this type activity.

The Studies and Analysis (S&A) FCRCs now only comprise about 15% of the program. MIT Lincoln Laboratory is our only laboratory FCRC, comprising about 21% of the FCRC program. These type FCRCs are under manpower limitations and will remain approximately at the FY 1978 manpower levels.

The Department maintains a varying fiscal constraint on the SE/TD FCRCs (MITRE and Aerospace) in order to accommodate the changing SE/TD workload in Space, Command and Control and Communications Systems. This total SE/TD fiscal limit is adjusted annually using a three year average of changes made in the DoD Consolidated Telecommunications Program (CTP) and the Space Program as reflected in the DoD Annual Report "Space and Space-Related Program Data". The fiscal levels arrived at are allocated between the Services and Defense Agencies and reported to Congress in the budget justification material. The changes in the Space, Command and Control and Communications RDT&E Program between FY 1978 and FY 1979 are as follows (dollars in millions):

	FY 1978	FY 1979
CTP	$ 569	$ 644
Space	844	1,261
Total	$1,413	$1,905

The planned increase is large in these programs. However, the three year averaging tends to moderate sharp changes in the FCRC SE/TD fiscal limits. We plan to increase SE/TD FCRCs program by 17% in FY 1979 to meet critical SE/TD support needs on these important programs.

In order to have a phased return to a relationship more closely aligned with the concept behind the original sponsorship of Aerospace and MITRE, the Air Force (executive agent of these FCRCs) is currently negotiating Memoranda of Understanding with the SE/TD Corporations on the type of and limits on the amount of work they can accept from non-DoD Departments and Agencies. It is anticipated that these negotiations will be completed by mid-1978 and an orderly process of evolution initiated to affect the agreed upon changes.

The Department considers the FCRCs to be a relatively small but highly important part of the Research, Development and Acquisition performance team. We do not plan to either reduce or increase the number of FCRCs sponsored and will continue close monitorship of this important segment of our program.

IV. Controls on the Export of United States Technology

Secretary of Defense Harold Brown issued an "Interim DoD Policy Statement on Export Control of United States Technology" on 26 August 1977. On 1 September 1977, I was assigned the responsibilities within DoD following from that interim policy statement for technology transfer, including COCOM planning and implementation, as appropriate, of the Defense Science Board Report of 4 February 1976 on export control of U.S. technology.

This will, for the first time, give my office, which has always had the responsibility for the Defense S&T Program, the responsibility also for technical aspects of our technology export control policies. This should make possible closer coordination between the DoD R&D efforts in support of critical technologies and DoD controls over exports of critical technologies. I anticipate a resulting better understanding of the processes for selecting critical technologies, for national support of these critical technologies and for more effective control over their export.

The recently issued DoD policy correctly highlighted the importance of technology and the dependency on it by military competitors or rivals as well as by commercial and business competitors. From my point of view, the policy also signalled the beginning of the end of a period where serious deficiencies marred our national handling of exports of technology; namely a period where emphasis was on the control of products and not of technology.

I believe, in this regard, that technology is a far more critical asset than are its products, which simply provide the tangible manifestations of the state-of-the-art of the technology. Technology, in this sense, can be described as the combination of "know-how" (practical knowledge), procedures, information, data, equipment and services required for (1) the design and manufacture of equipment and (2) the operation, maintenance and support accompanying successful product or service application.

Critical technology then refers to that small set of technologies whose acquisition by a potential adversary could make a significant contribution to the military potential of such a country and which would prove detrimental to the national security of the United States.

In the first six months under this new responsibility, my emphasis has been on:

1. Introducing the concept of "critical technology" as the dominant feature in our export control policy in order to (1) clarify the guidelines for processing export applications, (2) streamline the U.S. export control process and (3) make more effective and economic the export control process.

2. Developing a series of increasingly refined lists of candidate critical technologies to serve as the base for applying export controls. Technologies and associated products not deemed critical need not be subjected to DoD export control restrictions.

3. Identifying that small set of keystone equipment in each critical technology which cannot be exported because it (1) embodies in itself extractable critical technology or (2) is equipment that completes a process line and allows it to be fully utilized.

4. Identifying the largest set of equipment in each critical technology which may be exported without harm to U.S. national security and which will then assist U.S. industry in competing in an increasingly tough international marketplace, and

5. Developing a Technology Export Code of Practice which reflects DoD's national defense responsibilities and introduces meaningful and acceptable means of control over the many modalities of technology transfer.

As an indication of progress, we have issued two lists of candidate critical technologies. In the latest list, I have identified 9 candidate critical technologies for which, with wide industry participation (over 100 industry experts are involved), we will identify both the keystone equipment which should not be exported and the equipment which can be exported without harm to our national security.

The nine candidate technologies are:

- Array processor computer technology
- Acoustic array detection system technology

- Computer network technology

- Diffusion bonding technology

- High energy laser technology

- Infrared detection technology

- Large scale integration (LSI) integrated circuit (IC) production technology

- Jet engine technology, and

- Wide-body aircraft technology.

We have also identified a large set of products now controlled from export which are candidates for decontrol because we do not believe them to be keystone equipment. They are:

- Selected microwave equipment above one GHz

- Ion microscopes

- Selected semi-conductor manufacturing equipment

- Capacitors

- Wide-band VHF/UHF amplifiers

- Array processor computers with specified maximum processing speeds, and

- Thermal non-imaging detectors

We have reviewed some 120 individual requests for exports as well as 15 additional unusually significant and complex technology export cases.

Presently, there is a high level of activity underway in preparation for the 1978 COCOM List Review and for working with industry in all potential candidate critical technologies, since it is industry that owns or possesses most of the dual use technology which we are subjecting to export controls.

The process of introducing significant change into our export control procedures is difficult and lengthy, but the outcome will be worth the commitment of resources by both industry and government.

V. Concluding Comments

The FY 1979 budget request for the Defense S&T Program is $2.6 billion. The Defense S&T Program includes the DARPA Program and the DNA Program as well as the S&T Programs of the three Services.

The Program is closely coordinated with the Intelligence Community, DoD development organizations and operational commands. It is coupled with, and complementary to, the science and technology programs of the Departments of Energy and Transportation and of the National Oceanic and Atmospheric Administration and of the National Aeronautics and Space Administration. It relates well to similar programs pursued by our allies.

The S&T Program is a highly selective mix of high-risk, high-impact projects, of incremental advances in technology, of anticipated technological breakthroughs and of low-risk but urgently needed R&D. It runs the gamut from academic research to advanced full-scale technology demonstrations in operational environments.

The Program has the necessary diversity to provide us national comfort in our technological stature but its management is such as to ensure a surprising cohesiveness for such a large undertaking.

I believe it to be lean, responsive and responsible and submit it to you with considerable pride.